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Near Surface Bathymetry System. Report No. 11 in the ETL Series on Remote Sensing

Gunther Schwarz

NOVEMBER 1978

U.S. ARMY CORPS OF ENGINEERS
ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060

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This report describes the Near Surface Bathymetry System built under contract for Defense Mapping Agency - Hydrographic Center. Tests were performed to determine the characteristics and adherence to the specifications set forth in the Purchase Description. This report contains the results of these tests.

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PREFACE

The authority for the construction and tests described in this report is contained in project R4302 entitled "Near Surface Bathymetry by Multispectral Remote Sensing."

The tests were conducted by Gunther Schwarz, Photographer (Scientific and Technical) under the supervision of H.C. Babcock, Chief, Geographic Data Collection and Reduction Group. The tests were performed during May and June 1978.

The author wishes to thank the following personnel from the Defense Mapping Agency Hydrographic Center for their cooperation and assistance during the testing period: Mr. Stan McGee, Mr. Allan Layton, Ms. Kerry Malloy, and Mr. Joseph Kandrot.

The development of this system was for the then Defense Mapping Agency Hydrographic Center (DMAHC). Since that time, the Hydrographic Center has merged with the Defense Mapping Agency Topographic Center (DMAHTC). Although this work was done exclusively with the Hydrographic Center, the new name of the organization, i.e. DMAHTC, will be used throughout this report.

USAETL REPORTS IN THE REMOTE SENSING SERIES

Report No.	Author	Title	AD No.
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ETL - 0126	T.C. Vogel E.J. Books	A Selected Bibliography of Corps of Engineers Remote Sensing Reports (Rpt. No. 10 in the ETL Series on Remote Sensing)	AO49 351

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NEAR SURFACE BATHYMETRY SYSTEM

INTRODUCTION

SUBJECT

■This report covers the engineering tests of the Near Surface Bathymetry system. The purpose of the tests was to determine (1) the operational performance characteristics of the system and (2) the technical requirements as stated in appendix A.

BACKGROUND

For many areas of the world, hydrographic data is unavailable or inadequate. Many of the existing medium- and small-scale charts have been compiled using significant amounts of survey data that were collected before the advent of precision echo-sounding equipment. The LANDSAT imagery offers a rapid and inexpensive method for evaluating these charts for accuracy and completeness of shoreline and near surface features. The U.S. Army Engineer Topographic Laboratories (ETL) was tasked by the Defense Mapping Agency to develop a viewer system that would enable LANDSAT multispectral images to be projected in registration in a color additive viewer to form a color composite image that can be superimposed on hydrographic charts. Thus, medium- and small-scale charts could be compared with recent LANDSAT imagery to verify if the chart's portrayal of surface and near surface features, such as shorelines, reefs, shoals, and islands, is accurate and complete. The technical characteristics for the viewer system were developed by ETL and coordinated withDMAHTC personnel. The technical characteristics were then used to prepare a purchase description, which was entitled "Near Surface Bathymetry Multispectral System" and dated 3 January 1977 (appendix A). A developmental contract (DAAK70-77-C-0113 dated 29 April 1977) was awarded to International Imaging Systems (I^2S), a division of Stanford Technology Corporation, Sunnyvale, CA, to design and fabricate the system.

The system was delivered to DMAHTC on 17 May 1978. Tests were begun by ETL personnel on 22 May 1978. A test plan was prepared and used to determine the compliance of the system with the required technical characteristics (appendix B).

INVESTIGATION

GENERAL DESCRIPTION

■The Near Surface Bathymethry System consists of two major components; (1) a five-channel multispectral viewer/projector on a movable base, and (2) a modified horizontal Zoom Transfer Scope (ZTS), model ZT4, on a supporting table (figure 1). The dimensions of the viewer/projector with base are width, 50 inches (127 cm); depth, 49 inches (124 cm); and height, 75 inches (191 cm) at the lowered base position. The dimensions of the ZTS including the table are width, 60 inches (152 cm); depth, 30 inches (76 cm); and height, 66 inches (168 cm).

The five-channel viewer projects a set of three or four multispectral 70-mm (millimeter) images from a LANDSAT scene and one or two temporal images of the same scene by way of a front surface mirror and a beam splitting pellicle.[1] The scenes are superimposed and color coded by filters in such a way that a false color image is displayed on a 12- by 12-inch (30 by 30 cm) viewing screen. The image is then viewed by the operator by means of the ZTS, which in turn superimposes the LANDSAT scene on the image of a hydrographic chart. The chart is positioned on the table below the ZTS.

The viewer/projector portion of the system is mounted on a movable base (figure 3). The base can translate the viewer/projector for a total distance of 358 mm from side to side (X-axis), and it can raise (Y-axis) the viewer/projector for a total of 323 mm. The drive screw in the X-axis is powered by a 1/15-hp (horsepower) motor, which is attached by a belt to a pulley directly on the drive screw (figure 3). The Y-axis drive uses a 1/4-hp motor to drive a chain around three jack screws which form a three-point support for the movable base (figure 4).

The X- and Y-drive controls are remoted to a movable control box, which also has the ON/OFF, speed, and direction controls for each of the two motors (figure 5).

Optical System, Viewer/Projector. Two optical paths with different focal length lenses, condensers, and illumination sources are used in the multispectral viewer system. One optical path for the four primary LANDSAT images is as follows: Light that originates with the DAH 500-watt lamp is passed through a heat-absorbing glass, which reduces the heat transferred to the film; the light then passes through the filter and condenser system; the filtered light illuminates the film that is held in place by glass, proceeds through a Schneider 150-mm, f5.6 lens, (figure 6-M) and is reflected to the screen by a pellicle beam splitter (figure 6,N). The other optical path is for the image in the fifth channel, which is projected by a zoom lens (figure 6,K) to a front surface mirror (figure 6,L) that projects the image through the pellicle beam splitter to the viewing screen (figure 1,C). The effective magnification of all channels is 3.369X. In addition, each channel has an on/off switch, a filter control, and light intensity dial. To register the images

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[1] A temporal image is an image of the same scene, or subject, recorded on a different date. A series of temporal images can be used to determine whether a change in the scene is a temporary phenomena or a permanent feature.

on the viewing screen, each of the four primary channels has an X- and Y-translation control that is mounted on a front panel (figures 1,B and 7) and an image rotation ϕ knob that is attached directly to the image plate (figure 8).

The X-Y controls for the zoom lens are remoted to a movable control box (figure 1, E) which also contains the zoom control and a light-flickering control for all five channels. The main power switch is also located in this box (figure 9).

The cooling system for the viewer/projector consists of eight muffin fans that are located in the fan housing and that surround the lamps and optical system.

Zoom Transfer Scope. The ZTS is a modified Model ZT4-H manufactured by Bausch and Lomb. The ZTS 4-H has two image-viewing optics, a 2X magnification lens, and a reduction lens that reduces the image to 0.75 magnification. The reduction lens can be mounted over the 2X lens (figure 10). In addition, it has a 7:1 zoom capability, which enables images to be magnified from .75X to 14X on a continuous magnification scale. Using this zoom capability, the operator views the LANDSAT images and superimposes them on an image of a hydrographic chart.

The charts are viewed through interchangeable lenses of .75X, lX, 2X, and 4X(*figure 11,O). The ZTS also has an anamorphic* capability that can stretch the LANDSAT image up to 1:2X in any direction. Two tensor type lights illuminate the charts, which are mounted below the horizontal bar of the ZTS. The lights are controlled by an intensity dial (Figure 11,Q) and a on/off flicker switch (figure 11, P).

The table supporting the ZTS has a set of tracks with a front position stop and a rear position stop. The front positon stop is used for focussing the 2X image lens; the rear position stop is used for focussing the .75X image lens.

Principle of Operation. The Near Surface Bathymetry System is operated as follows. The LANDSAT scene of interest is placed in the film holders (figure 12). After channels 1 and 2 are illuminated, the two images are superimposed by the X, Y, and ϕ controls. To check the accuracy of this operation, the flicker switch for either channel 1 or 2 can be used. If the images do not align correctly, one or the other image appears to have a flickering movement.Once the two images are aligned, channel 2 is turned off and channel 3 is turned on. The procedure continues until all four channels are superimposed and form a single image. If a temporal scene is used, it is put into channel 5 (zoom channel) and the same procedure

for alignment is followed. If a scale change is necessary for channel 5, the zoom lens capability is to be used to match the scale of the other four channels. When the above procedure is completed, color filters are then rotated into position to color code the scene as required.

A hydrographic chart of the same area as the LANDSAT image is then placed under the ZTS, and the appropriate map lens (see optics selection guide below) is inserted into the ZTS. The operator views both the LANDSAT image and the hydrographic chart through the viewing optics located in the front of the ZTS. By means of the X and Y viewer/base motion, the operator finds the identical area on both the LANDSAT and chart and then scales the LANDSAT image to fit the area on the hydrographic chart.

OPTICS SELECTION GUIDE

OPTICS	RANGE OF CHART SCALE
WITH .75 X Map Lens	
WITH .75 - 5X Image Lens	1:999,999 - 1:150,000
WITHOUT .75 - 5X Image Lens	1:375,000 - 1:53,571
WITH 1 X Map Lens	
WITH .75 - 5 X Image Lens	1:1,333,333 - 1:200,000
WITHOUT .75 -5 X Image Lens	1:500,000 - 1:71,428
WITH 2 X Map Lens	
WITH .75 - 5 X Image Lens	1:2,666,666 - 1:400,000
WITHOUT .75 - 5 X Image Lens	1:1,000,000 - 1:142,856
WITH 4 X Map Lens	
WITH .75 - 5 X Image Lens	1:5,333,332 - 1:800,000
WITHOUT .75 - 5 X Image Lens	1:2,000,000 - 1:285,712

The map lens is underneath ZTS and views the charts. The image lens looks at the LANDSAT image on the screen.

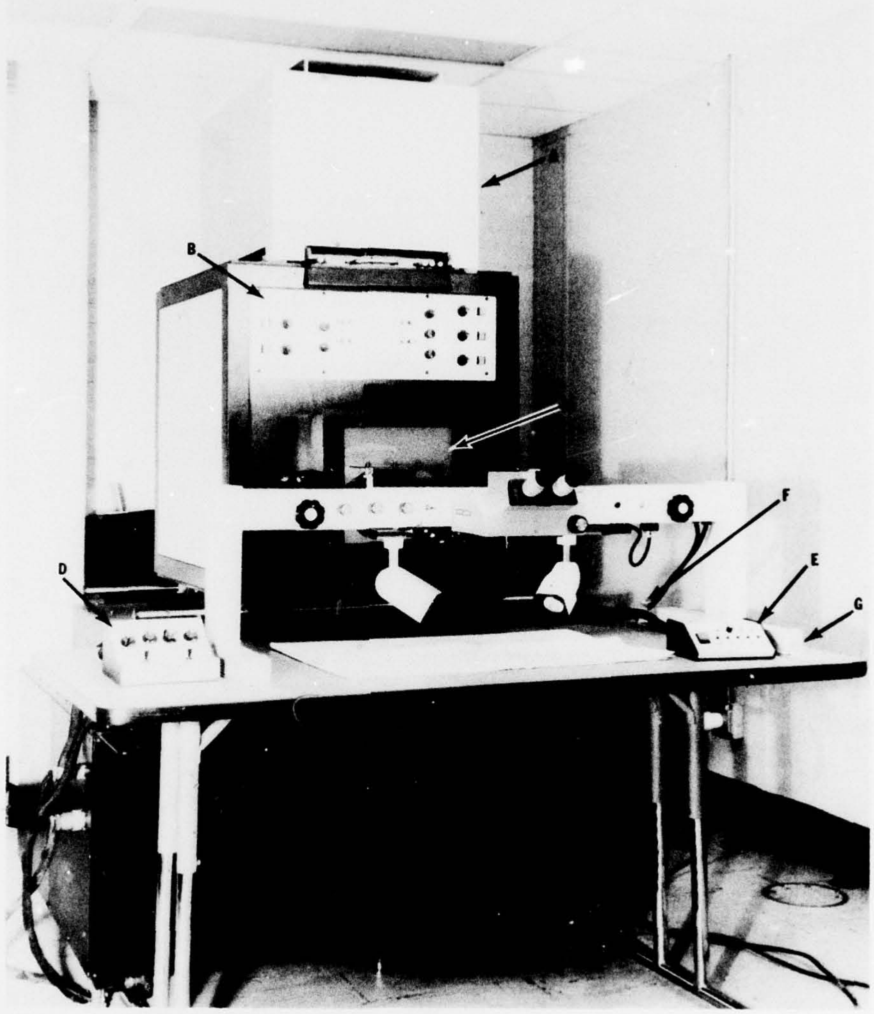

Figure 1. Complete System with ZTS

A - Fan Housing
B - Image Registration and Illumination Controls
C - Viewing Screen
D - X and Y Viewer Base Movement Controls
E - Zoom Lens and Flicker Controls
F - Front Stop for ZTS Focus
G - Rear Stop for ZTS Focus

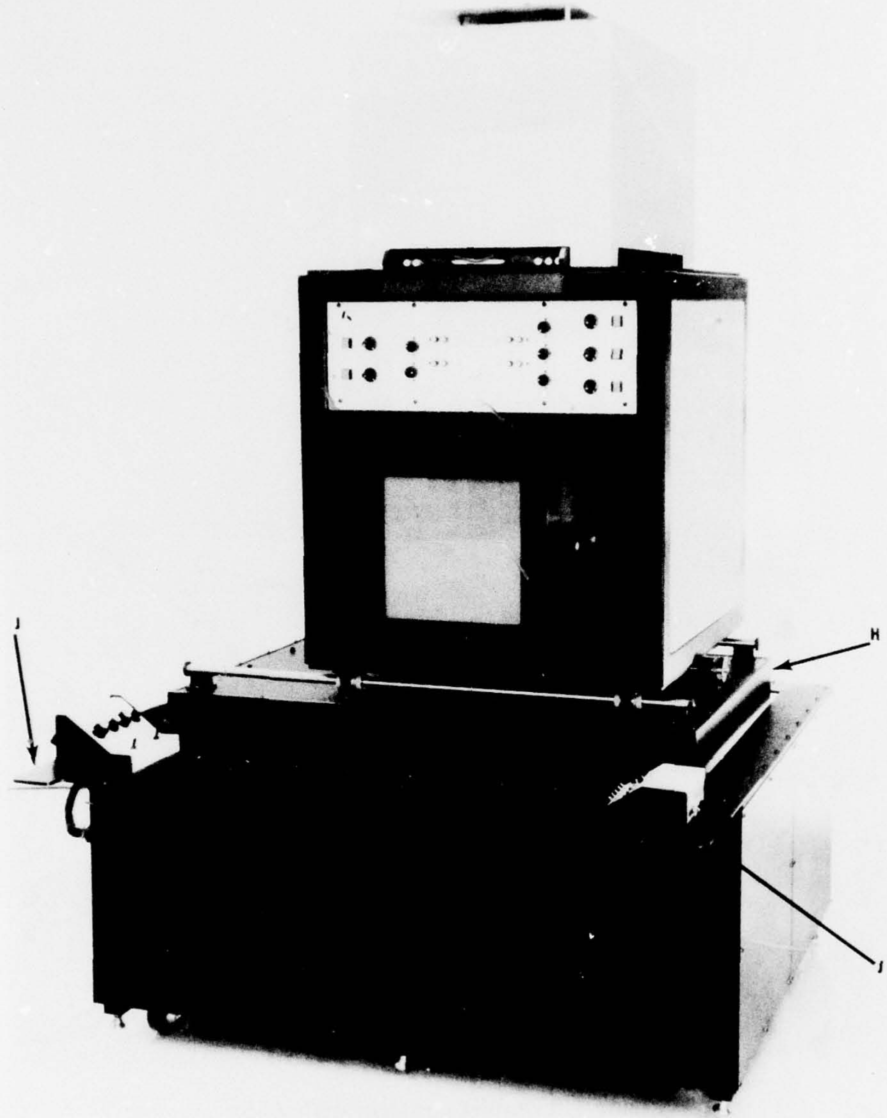

Figure 2. Viewer Projector and Base

H - Movable Base
J - Discrete Distance Plates for ZTS Table Alignment

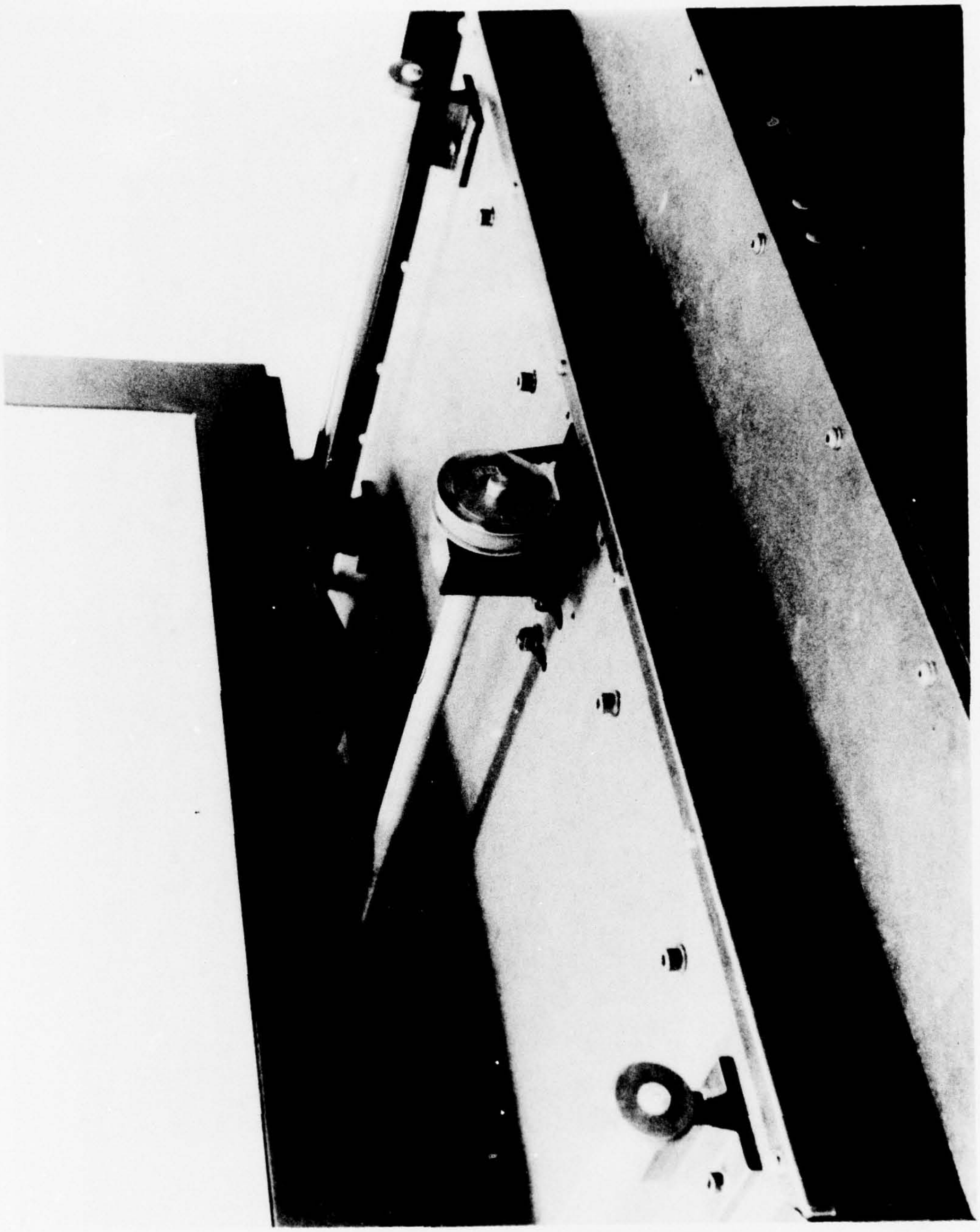

Figure 3. X Axis Drive Pulley

Figure 4. Y-Axis Drive Motor and Gear

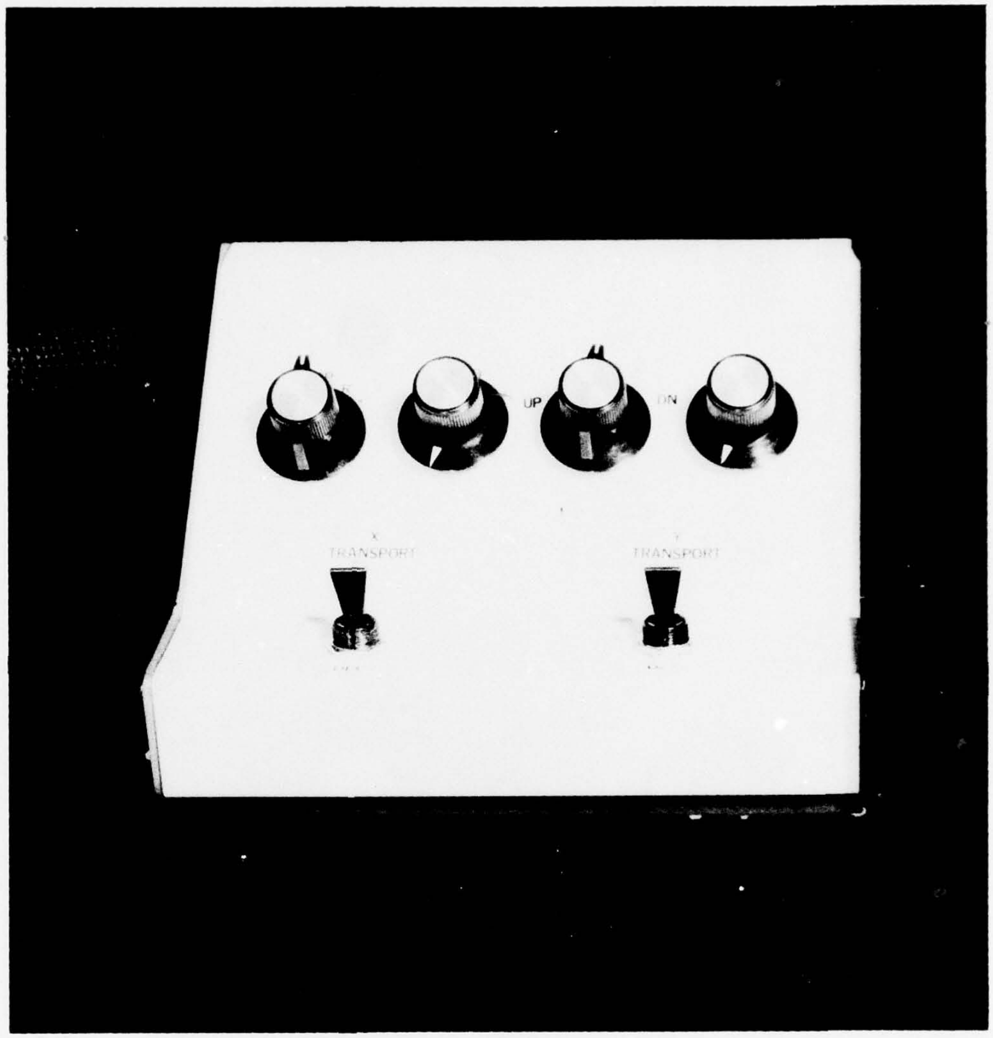

Figure 5. X,Y Drive Controls

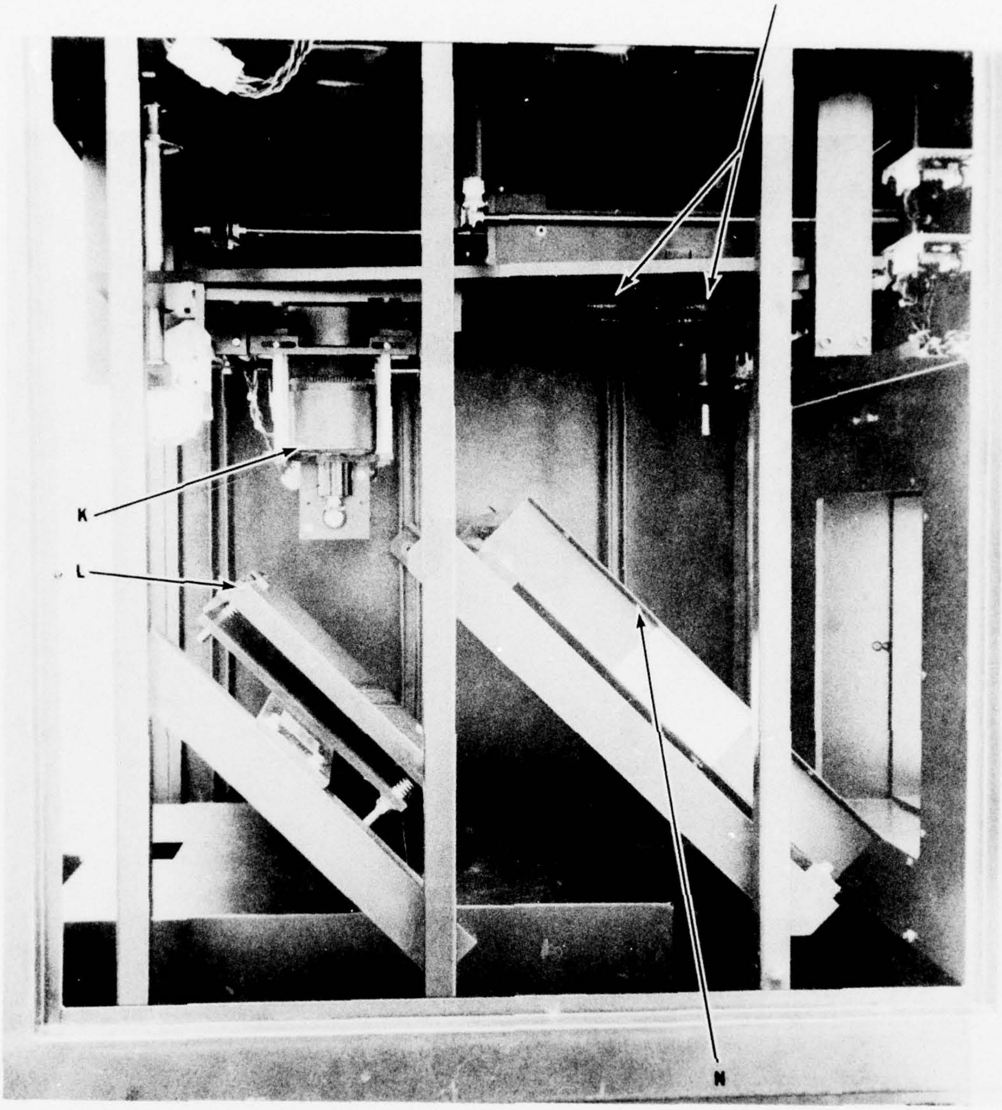

Figure 6. Viewer/Projector Internal View

K - Zoom Lens
L - Front Surface Mirror
M - 150 mm Lenses
N - Pellicle Frame

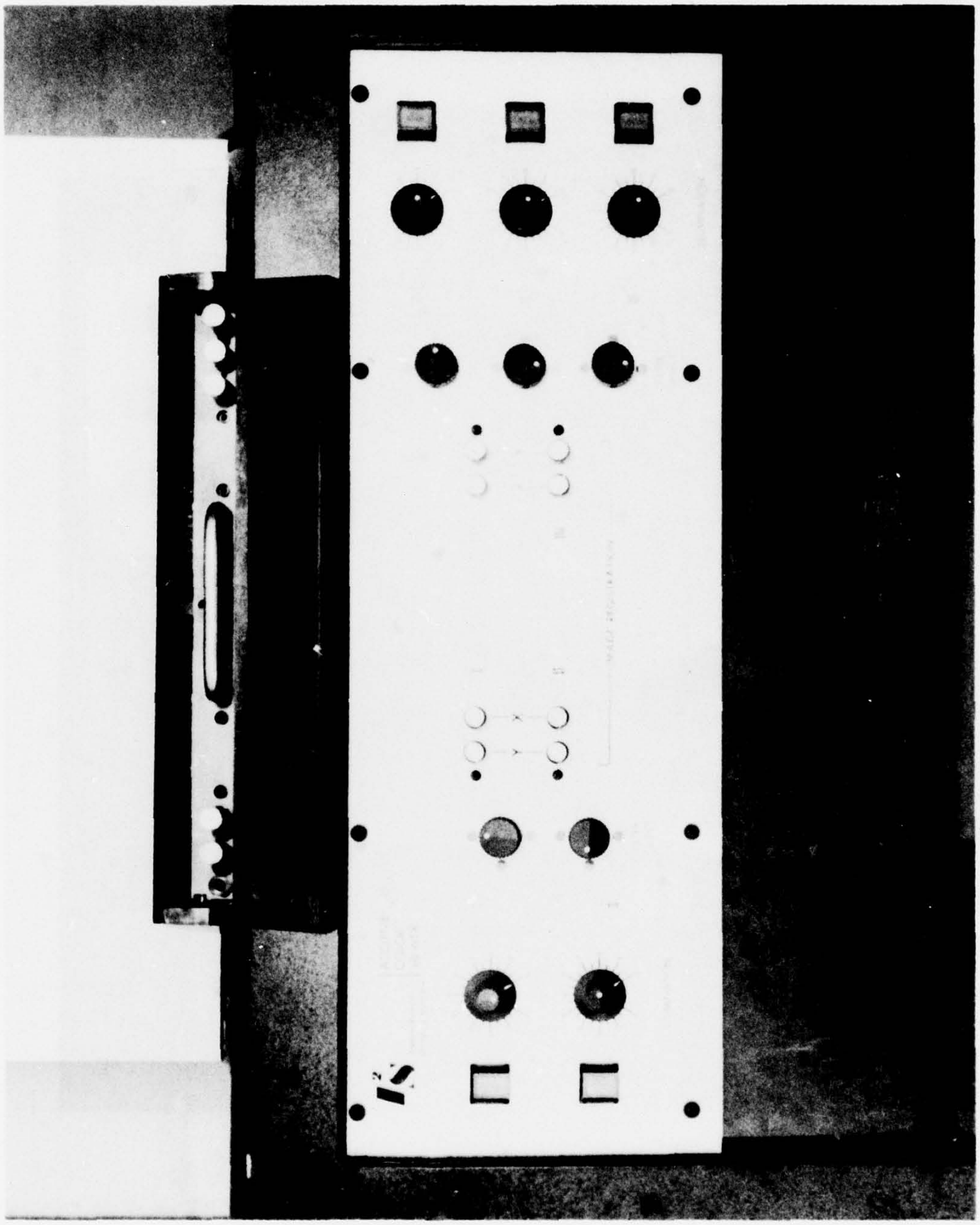

Figure 7. Viewer Projector Controls

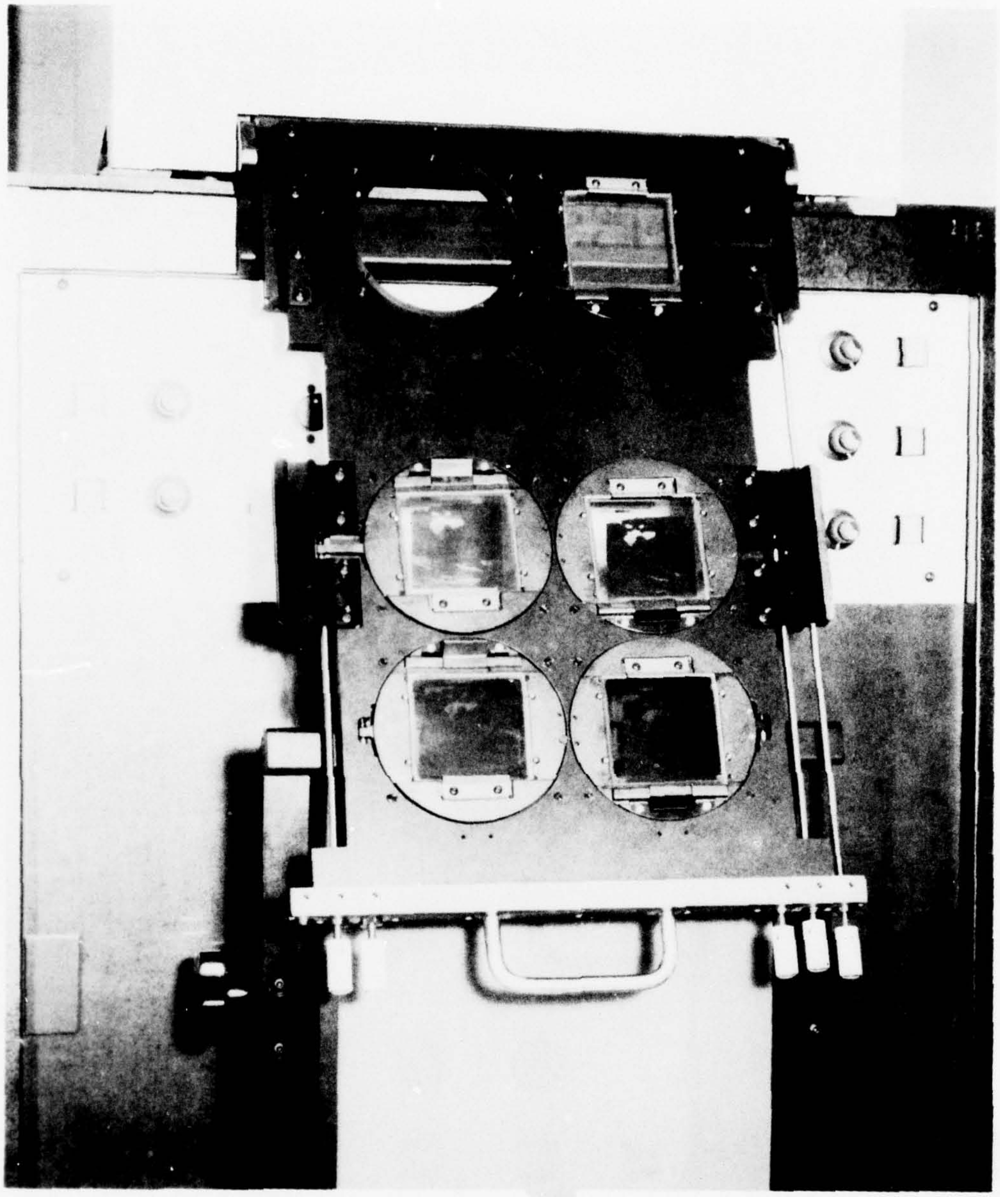

Figure 8. Theta Plate with Photographic Images

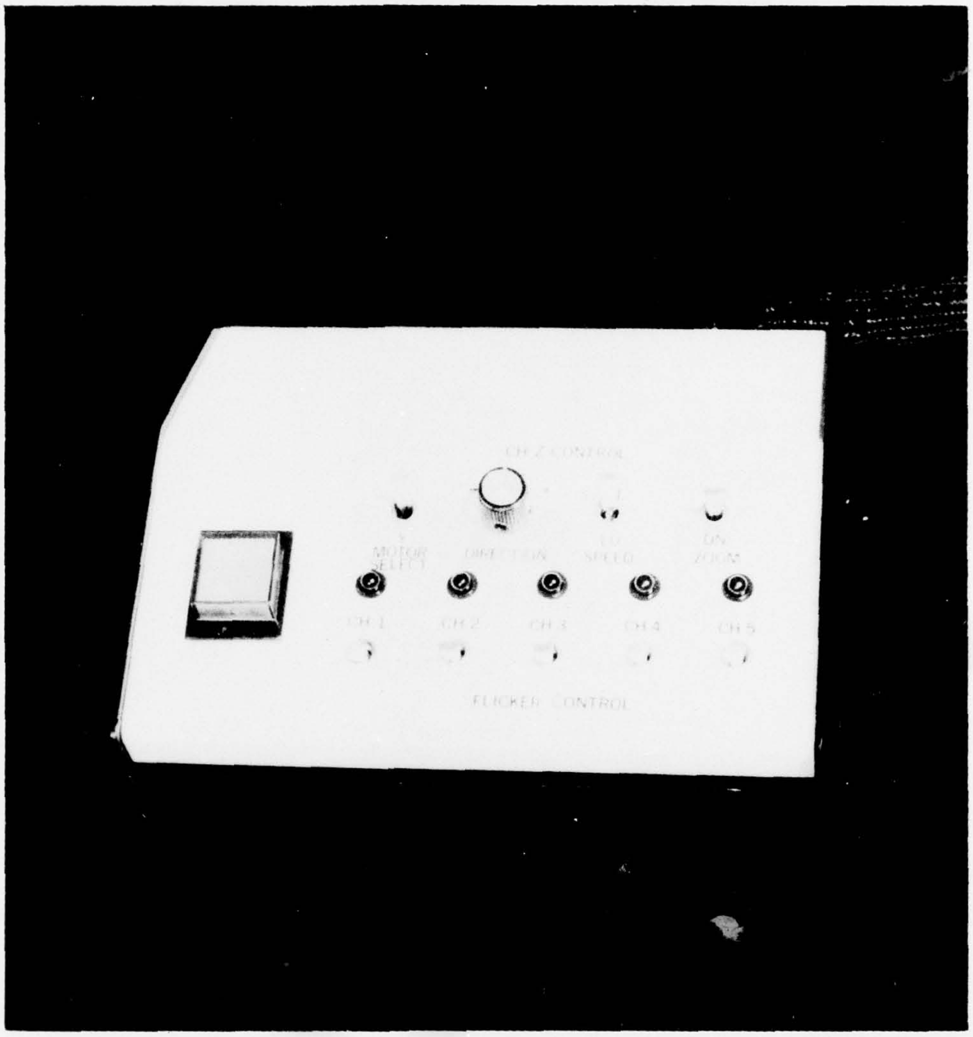

Figure 9. Zoom Lens and Flicker Control

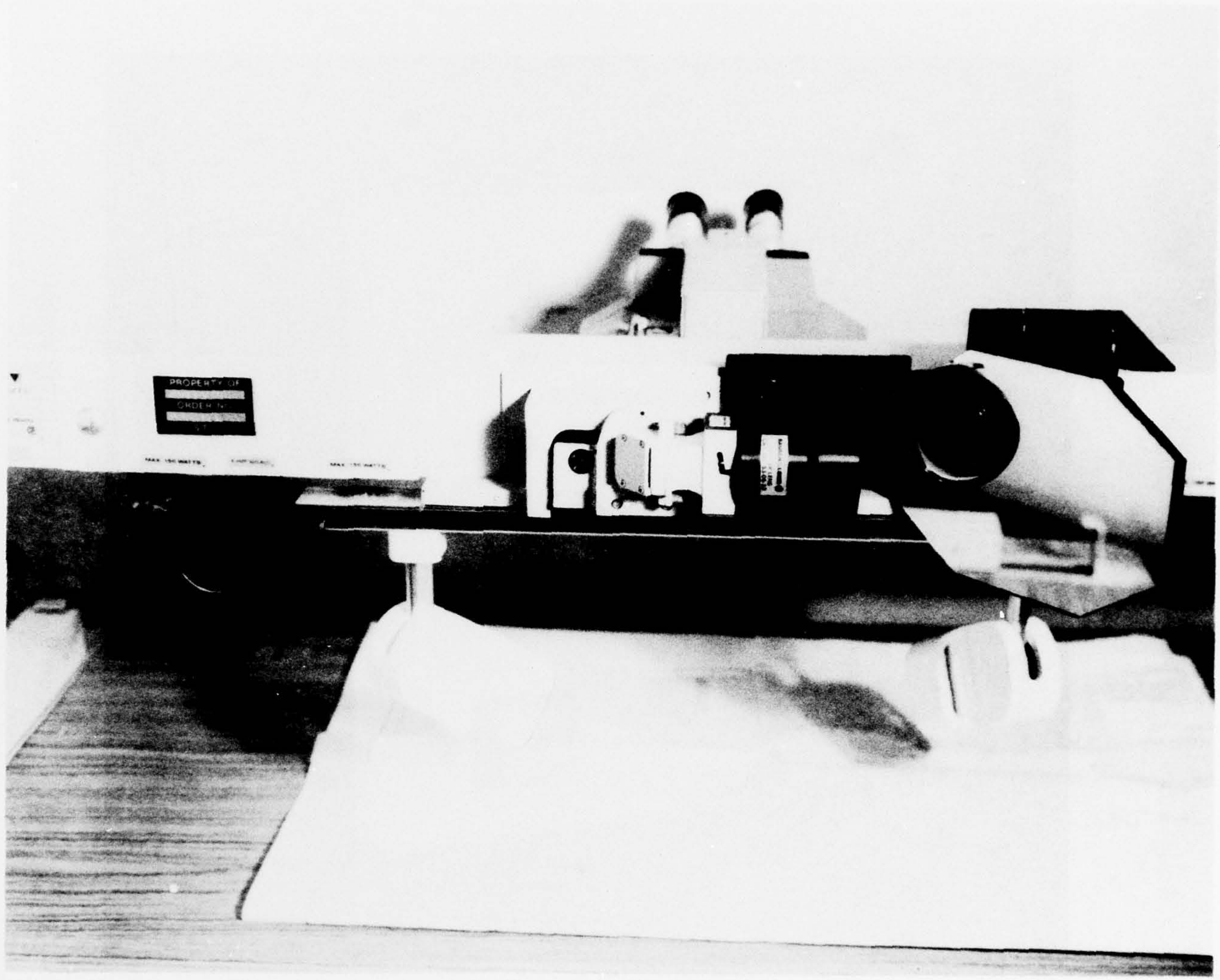

Figure 10. Image Viewing Pickup Optics

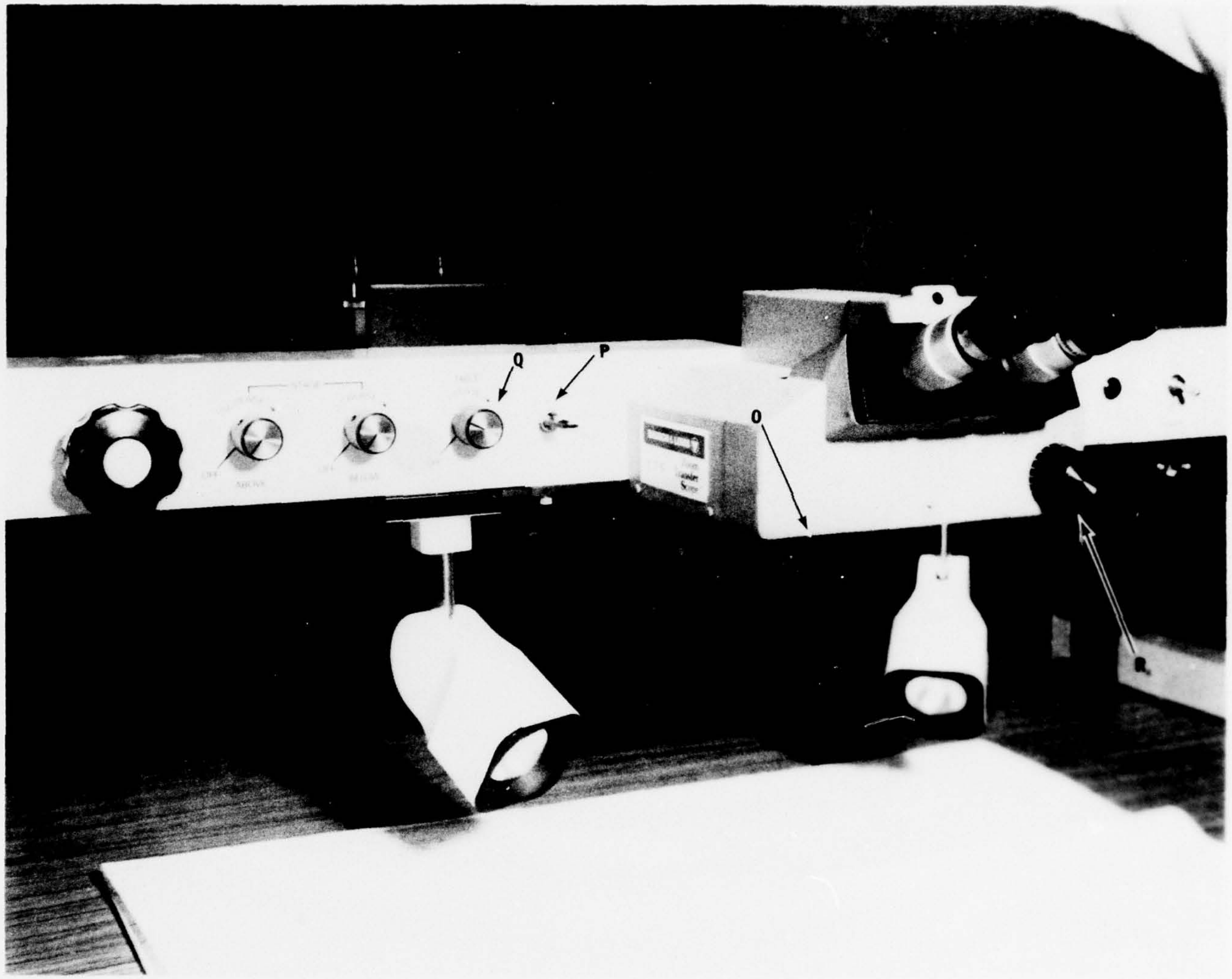

Figure 11. ZTS Stereo Viewing and Controls

O - 1X Map Lens
P - Chart Illumination Flicker Switch
Q - Chart Illumination Control
R - ZTS Zoom Dial

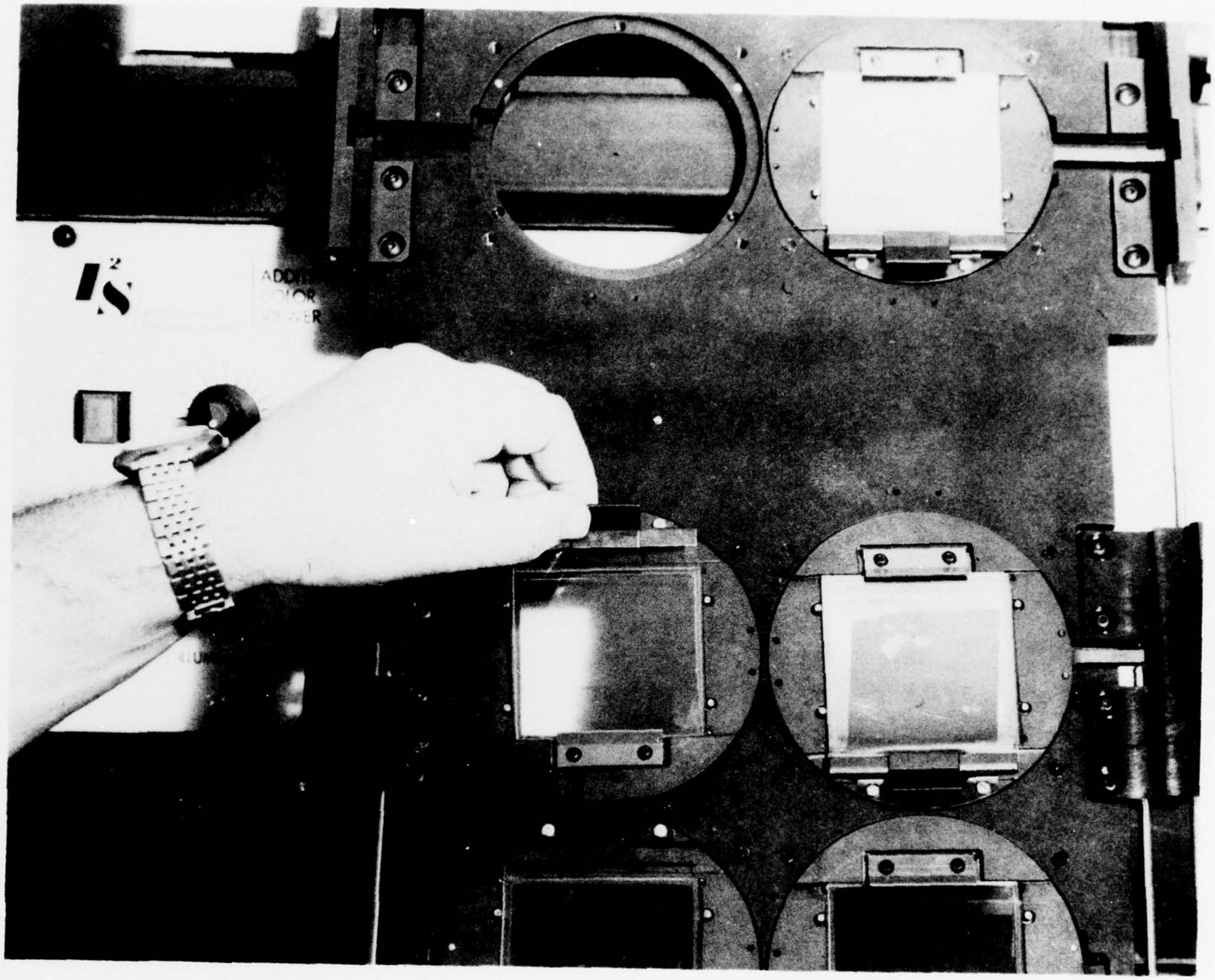

Figure 12. Photographic Image Holder

TESTS AND TEST RESULTS

OPTICAL ALIGNMENT

Viewer/Projector. The purpose of this test was to determine the accuracy of the optical alignment of the five channels and the relative distortion characteristics of each optical path.

Procedure. A set of identical grids having a line width of .001 inch (0.03 mm) were placed in each of the five channels, and through the use of the X, Y, and ϕ motions, the grid lines were superimposed on each other.

Results. All Projected grid lines were superimposed on each other without noticeable variation in line width. Therefore, the distortion characteristics of each channel are well within acceptable limits.

Zoom Transfer Scope. The purpose of this test was to determine the ZTS's capability to superimpose an image optically from the viewing screen with an image on the chart table.

Procedure. A precision grid having line intervals of 22.5 mm was placed on the front surface of the viewing screen, and an identical grid was placed underneath the ZTS. A 1X magnification map lens was inserted for viewing the grid under the ZTS and a .75X image lens was used for projecting the grid from the viewer screen. The grid from the screen was zoomed to a matching scale. After observing the matching capability, the grid under the ZTS was replaced by a millimeter scale, and the zoom was set at 1X and 7X. The grid image from the screen was then compared to the millimeter scale. This test was repeated with the 2X image lens.

Results. In the X-axis, the grid from the front of the viewing screen and from the chart table matched well, but in the Y-axis the grid from the viewer screen appeared to be larger. The results of the measurements showed that the compared square area was 67.5 mm in the X-axis and 69 mm in the Y-axis. This difference was due to a faulty anamorphic control. The problem was corrected by technical personnel from Bausch and Lomb, and the grids can now be matched in both X- and Y-axis.

The measurements at the 1X and 7X zoom were as follows:

Image Lens	Zoom Scale Setting	Distance of Grid Intervals (mm)	Theoretical Magnification (mm)	Actual Magnified Grid Interval (mm)
.75X	1X(.75X)	135.0	101.250	99.0
.75X	7X(5.25X)	22.5	118.125	115.0
2X	1X(2X)	67.5	135.000	131.0
2X	7X(14X)	22.5	315.000	319.5

X-Y Drive. Two tests were made to check the X-Y drive performance requirements (see appendix A, paragraph 3.2.1).

Procedure. In the first test, with the viewer on the extreme right side, the X-drive was turned on until the viewer reached the extreme left side. The distance traveled was then measured. In the second test, the viewer was lowered to the lowest position and after using the Y-drive, was raised to the highest position. This distance traveled was then measured.

Results. The total distance the viewer moved in the X direction was 358 mm. In the Y direction, the viewer can move 323 mm. The specifications require the viewer to move a minimum of 250 mm in the X and in the Y direction.

Image Transfer Test. **Procedure.** After placing a set of LANDSAT images in the viewer/projector and a corresponding hydrographic chart(s) under the ZTS, the quality of the projected image was observed as it was superimposed on the chart(s) using black and white projection mode. Illumination was set at maximum and the map illumination was flickered for best matching.

Results. The LANDSAT imagery and the hydrographic chart could be aligned and superimposed with little difficulty.

ZTS ZOOM CAPABILITY This test was performed to determine the ZTS zoom capability and the viewer/projector zoom capability.

Procedure.	A LANDSAT image set was projected onto the viewer screen. This image was then superimposed by means of zooming and changing map lenses so that a series of charts, each one having a different scale, could be matched.
Results.	The LANDSAT imagery was matched to charts having the following scales: 1:60,000; 1:125,000; 1:250,000; 1:952,800; 1:1,800,000; and 1:2,921,400.
Viewer/Projector Zoom	**Procedure.** By using the same LANDSAT scene as the primary image, an additional LANDSAT scene of the same area was inserted into the zoom fifth channel at the viewer/projector to match the scale with the primary image.
Results.	After some X, Y, and ϕ adjustments, the temporal scene matched the scale of the primary image with little difficulty.
Temporal Scene Change Detection.	**Procedure.** A set of LANDSAT images was placed in channels 1 to 3. The set consisted of bands 4,5, and 7. Images of the same area recorded approximately 15 months later were placed in channels 4 and 5. These images consisted of bands 4 and 7. After all images were aligned, the flicker controls were used to determine changes in the water and land areas.
Results.	The differences between images made on different dates were quite evident, especially when the images were color coded by filtration and when the contrasting colors were flickered. The water areas showed different turbidity between dates. In addition, what at first looked like a small bay on an island was determined to be a cloud shadow.

DISCUSSION ▪The near Surface Bathymetry System was tested at DMAHTC where equipment was delivered. The tests were conducted to determine if the contractor had met the requirements set forth in the Purchase Description. In testing the optics of the system, the viewer and ZTS had to be considered individually so that any problem could be traced to its source. Although it was not specified in the Purchase Description (appendixA), the manufacturer's specifications required that the image matching must be accurate within one line width (.001 inch, or .03 mm). This accuracy requirement was met.

The capability of the ZTS to superimpose an image from the viewer screen was not accurate. Test results showed that the grid projected from the screen was 2.3 percent larger in the Y direction. This error was traced to the anamorphic lens in the ZTS. Also, a slight stretching of the image was present, even when the "stretch" setting was at 1:1. However, after a Bausch and Lomb technical representative was called, the above problems were solved. The zoom capability of the ZTS was checked, and it was found that the actual magnification did not match the indicated magnification on the zoom control. However, since the operator looks at the chart for matching scale and not the zoom dial, this discrepancy is not a significant factor.

The image that is projected on the viewing screen is at a scale of 1:1,000,000. Because the Bathymetry System can accommodate charts from 1:53,571 to 1:5,333,333, a method of enlarging or reducing the chart scale and the scale of the LANDSAT image is incorporated in the system. Some of the scales prevent the operator from viewing the entire LANDSAT image at one time. In order that the operator can view sections ofthe LANDSAT images, the viewer must be able to travel 125 mm in each direction from a center point. The results are well beyond this required distance. The matching of charts between 1:60,000 and 1:2,921,400, which were used during the tests, presented no problem.

During the tests, it was noted that when superimposing LANDSAT imagery over a hydrographic chart, it was easier for the operator to match images when using Band 7 (IR) in the black-and-white mode. The reason for this was that the high contrast between water and land showed a well-defined sharp shoreline. However, with the underwater information from bands 4 and 5, the matching was more difficult. Figure 13 shows what the operator sees when working with Bands 4 and 7. Once the matching is accomplished, the other information may be superimposed, and color coding may be done by means of the filters.

One test that was conducted determined how a temporal scene matches the primary scene when the fifth channel (zoom lens) is used. The results of this test showed that relatively little scale change was needed to match the temporal scene to the primary scene. It was apparent that the light-flicker capability of each channel helps to pinpoint differences between scenes of the same area. For example, what appeared to be a bay on an island in one scene did not appear on a temporal scene. It was first assumed that one scene had been recorded with the tide in and the other with the tide out. This theory was quickly disproved by color filter changing and flickering. The problem was caused by a cloud shadow so situated as to give a strong appearance in the IR channel of a bay. In addition, certain water information, such as turbidity and wave action, can also be detected as differences in the temporal scenes.

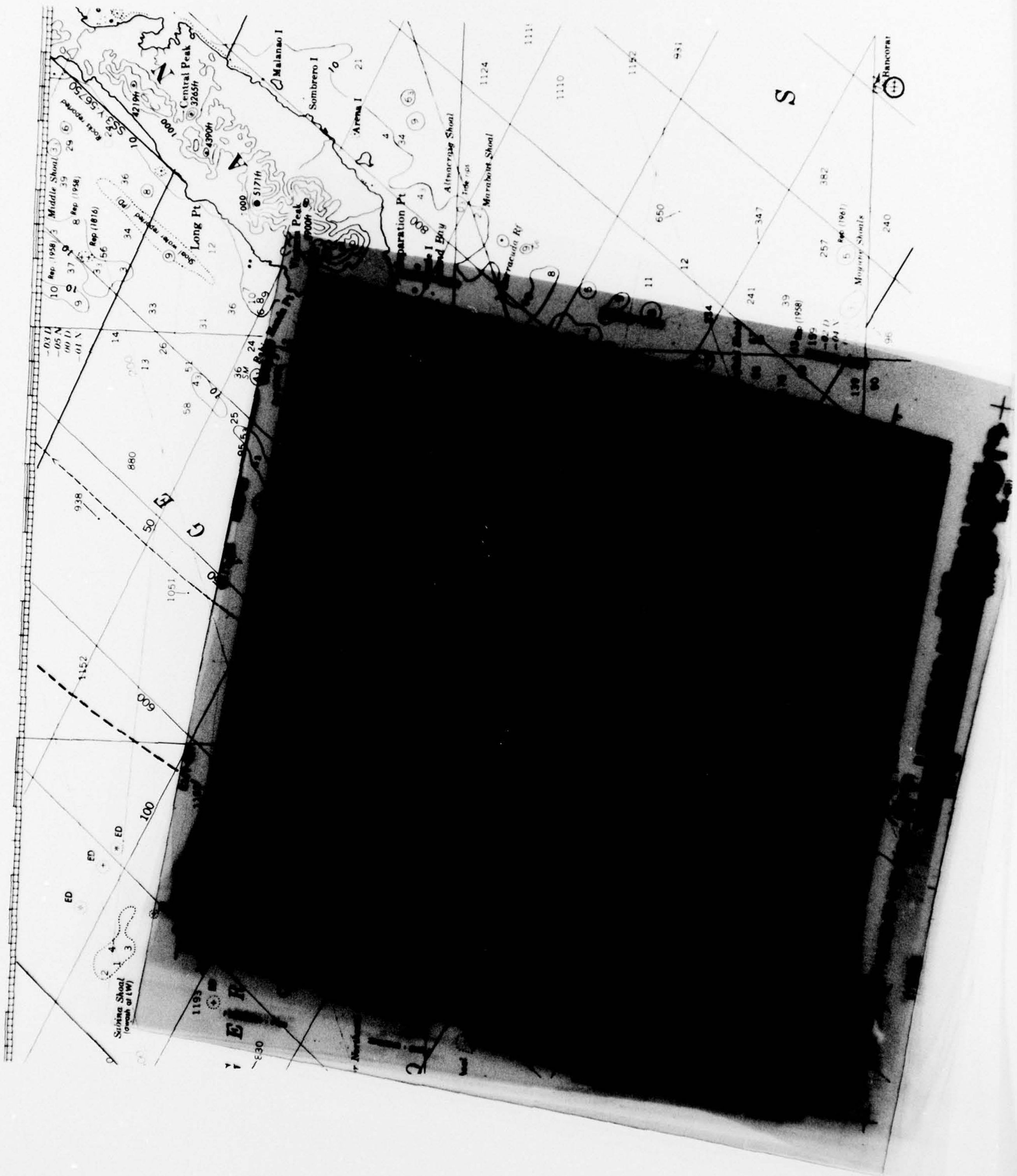

Figure 13. LANDSAT Image Superimposed on Hydrographic Chart

Some problems that occured with the system were eliminated by modifications and additions. For example, a cooling fan vibration caused the images on the screen to vibrate intermittently so that at times it was impossible to view or match the LANDSAT imagery. This problem was solved by installing flexible styrofoam on the inside walls of the fan housing. In addition, the contractor failed to install microswitches to stop the motion or to alert the operator when the X and Y motions of the viewer were near the limits. This problem was solved by having a DMAHTC technician install a set of microswitches, which now enable the operator to stop the motion and to have an audible alert sounded when the motions approach the limits.

Although the system functions properly, some problems exist that must be addressed before this system can be used to its full potential. One problem concerns the geometry of the LANDSAT images. How accurately the Space Oblique Mercator (SOM) projection can be adapted or converted to other projection systems, such as the Universal Transvers Mercator (UTM), is yet to be determined.

Another problem is bridging, or otherwise associating, a given LANDSAT scene with its true position on the earth's surface. This problem is compounded by the minimal control data available in scenes that show little land area.

CONCLUSIONS ■It is concluded that

1. The Near Surface Bathymetry System met all requirements as stated in the Purchase Description.

2. All problems with the system have been corrected.

3. The system delivered to the Defense Mapping Agency - Hydrographic Center (DMAHTC) meets all requirements requested byDMAHTC.

4. The system provides a means for comparing LANDSAT images to existing hydrographic charts. However, based on the results of the tests of this system, it is not clear whether the discrepancies between the LANDSAT images and the hydrographic charts were due to errors on the charts or the geometry of the images.

APPENDIX A. PURCHASE DESCRIPTION

U. S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060

ETL-GS-P   4 January 1977

GEOGRAPHIC SCIENCES LABORATORY
Data Processing and Products Division
Geographic Data Collection and Reduction Group

Near Surface Bathymetry Multispectral System

1. Scope. This PD defines the requirements for the design and fabrication of a viewer system to be used for the evaluation, comparison, and annotation of hydrographic charts with LANDSAT imagery.

2. Background. For many areas of the world, hydrographic data is unavailable or inadequate. Many of the existing medium and small scale charts have been compiled using significant amounts of survey data that was collected before the advent of precision echo sounding equipment. The LANDSAT imagery offers a rapid and inexpensive method for evaluating these type of products for accuracy and completeness of shoreline and near surface features. The U. S. Army Engineer Topographic Laboratories has been asked to develop a viewer system that will allow LANDSAT multispectral images to be projected in registration in a color additive viewer to form a color composite image which can be superimposed on hydrographic charts. This will permit medium and small scale charts to be evaluated against recent LANDSAT imagery as to the accuracy, currency, and completeness of the portrayal of surface and near surface features such as shorelines, reefs, shoals, and islands.

3. Requirements.

3.1 Description. The system shall consist of a commercially available, modified, additive color viewer and a Bausch & Lomb Zoom Transfer Scope (ZTS) Model ZT4-H interfaced to form a complete system. The ZTS will have two (2) zoom magnification scales, .75 - 5.25X and 2 - 14X. It will also have interchangeable chart lenses for .75, 2, and 4X mangification.

3.2 Viewer. The viewer shall be able to take a minimum of five (5) black and white spectrally separated 70 mm film positives and project color filtered black and white images so that a combination of the projected images forms a composite color image on a rear projection screen. Each channel must have an on-off flicker device so that images having temporal changes may be compared.

3.2.1 The viewer shall be capable of movement in an X and Y direction to a minimum distance of 125 mm from the center point of the screen. This movement shall be independent of the ZTS so that all areas of the projected image on the screen may be viewed through the ZTS at various scales. Also, a front to rear motion of least 125 mm must be included for focussing purposes when different lenses are to be used in the ZTS.

3.2.2 Controls. All control switches, knobs, buttons, etc. must be easily accessible from the operator's normal working position.

3.3 Zoom Transfer Scope. The ZTS to be interfaced will be a Bausch & Lomb Model ZT4-H and will be Government Furnished Equipment. The ZTS must be modified by the contractor so that the mirror transfers the image from the viewing screen to the optics of the ZTS. Other modifications must be made on the ZTS to eliminate components not needed for the described task and to add on whatever is needed for the interfacing of the viewer and ZTS. It is preferred that the ZTS be attached to the viewer if such attachment does not

interfere with other requirements. The capability to lay charts or other data below the ZTS must be maintained.

3.4 Instruction Manuals. Two sets of instruction manuals for the viewer portion of the system including trouble shooting techniques shall be furnished.

3.5 Human Engineering. The above system shall be modified in accordance with good human engineering practices. Human factor engineering considerations shall include but not be limited to the following factors: Environmental conditions, safety including electrical and mechanical, display and control panel layout, labeling component arrangement, and accessibility for maintenance.

3.6 Reliability. The system shall provide maximum possible inherent reliability consistent with existing state-of-the-art and shall demonstrate to the satisfaction of the Contracting Officer's Technical Representative that a high degree of system reliability has been attained.

3.7 Standard Products. Where feasible, components shall be standard commercial products so that prompt and continuing service and delivery of spare parts may be assured.

3.8 Instruction Plates. The system shall be equipped with instruction plates, including warnings, cautions, suitably located, describing any special or important procedure required for operating and servicing.

3.9 Workmanship. Workmanship shall be in accordance with good commercial practice for this type of equipment.

4. Quality Assurance Provision.

Inspection. The system shall be subjected to inspection by Government representatives during and after manufacture to determine conformance with the requirements of this Purchase Description.

APPENDIX B. Test Plan

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060

ETL-GS-P 8 May 1978

GEOGRAPHIC SCIENCES LABORATORY
Data Processing and Products Division
Geographic Data Collection and Reduction Group

PLAN OF TEST
FOR
NEAR SURFACE BATHYMETRY MULTISPECTRAL SYSTEM

1. PURPOSE. The purpose of this test is to determine the capability of the Near Surface Bathymetry Multispectral System (NSBMS) to use LANDSAT imagery for updating hydrographic charts and to determine the conformance to the specifications defined in the Purchase Description dated 3 January 1977.

2. REFERENCES.

2.1 Purchase Description - Near Surface Bathymetry Multispectral System dated 3 January 1977.

2.2 U.S. Army MERADCOM Contract, Contract No. DAAK70-77-C-0113 dated 29 April 1977.

3. PLAN OF TEST.

3.1 General. Test of the NSBMS will consist of optical alignment test for both the viewer and zoom transfer scope (ZTS) portions of the system, image tansfer test, X-Y motion test of base, zoom tests of both viewer and ZTS temporal scene change detection, ease of operation and maintenance.

3.2 Optical Alignment.

3.2.1 Procedure. Place a set of identical grids into each projection channel. At the point of best focus for each channel, determine the capability of the viewer to superimpose all five grid images on the viewing screen so it appears as a single line grid. Placing an enlarged version of the same grid under the ZTS, transfer the image from the screen to the enlarged grid under the ZTS. Note any difficulty.

3.3 X-Y Motion Test.

3.3.1 Procedure. With the viewer movement adjustment control, place the viewer on one extreme end of the X and Y axis; using the X and Y controls, move the viewer to the other extremes of the axis; measure and record the total distance the viewer has moved from one extreme to the other. With a LANDSAT image placed in the viewer and a set of corresponding hydrographic charts of various scales, determine the amount of viewer motion needed to cover the charts.

3.4 Image Transfer Test.

3.4.1 Procedure. Using a set of LANDSAT images in the viewer and placing a corresponding hydro-chart(s) under the ZTS, observe the quality of the projected image as it is superimposed on the chart(s). Record the illumination setting needed to optimize the image.

3.5 Zoom Capability.

3.5.1 ZTS Zoom. Using the same LANDSAT images as in 3.4.1, superimpose the scene on the corresponding charts of various scales. Observe and record the ease of zoom adjustment in the ZTS, the accuracy of matching the LANDSAT scene to the scale of the chart and the extreme chart scales that can be used.

3.5.2 Viewer Zoom. Using band 4 from a scene of the same area in channels 1, 2, 3, and 4 but of a different date, check the scaling capability of channel 5 by "zooming" the lens in channel 5 until a scale match is accomplished for channel 5 and the other four channels.

3.6 Temporal Scene Change Detection.

3.6.1 Utilizing the same set up as in 3.5.2, flicker the lights between channel 1 and 5. Determine whether any changes are present in the two scenes. If so, note the ease or difficulty of detection, what color filters are the best to use. If no scene change can be detected, find a set (different dates incl.) that has temporal scene changes and repeat the test.

3.7 Ease of Operation.

3.7.1 Note the location of all controls. Determine the ease of "loading" the viewer. Record all observation pertaining to the human engineering or lack of it.

3.7.2 Maintenance. Determine the need the preventive maintenance and high mortality part. Make list of spare parts that might be needed to keep system operating.